

Amendments to the Claims

The listing of claims will replace all prior versions, and listings of claims in the application.

1. (Currently Amended) An integrated circuit (IC) output stage protection system, comprising:

a first NMOS device, having a gate configured to be coupled to an output of an IC logic core and a source coupled to a current source;

a second NMOS device, having a source coupled to a drain of said first NMOS device and a gate coupled to a biasing circuit that biases said second NMOS device so that said-first NMOS device operates in a saturation region; and

one or more diodes coupled between an output node and a gate of a third NMOS device, having a source coupled to a drain of said second NMOS device and a drain coupled to said output node, wherein said one or more diodes substantially protect said NMOS devices so that they operate within a device voltage rating;

wherein an operating voltage of said first NMOS device is lower than an operating voltage of said second NMOS device, and wherein said operating voltage of said first NMOS device is lower than an operating voltage of said third NMOS ~~device;~~ device.

2. (Previously Presented) The IC output stage protection system of claim 1, wherein said one or more diodes are coupled to said gate of third NMOS device through a resistor.

3. (Previously Presented) The IC output stage protection system of claim 1, wherein at least one of said one or more diodes comprises an NMOS device configured as a diode, said NMOS device having a guard ring coupled to first and second contacts on a P-substrate.

4. (Original) The IC output stage protection system of claim 1, further comprising:

an input/output (I/O) pad electrostatic discharge (ESD) protection circuit coupled to said output node.

5. (Previously Presented) The IC output stage protection system of claim 4, wherein said I/O pad ESD protection circuit comprises:

a first set of one or more diodes coupled between an I/O pad and a local net;

a second set of one or more diodes coupled between a ground and said I/O pad;

an NMOS device having a drain coupled to said local net, a source coupled to said ground, and a gate coupled to an output of an inverter;

a first resistor coupled between said local net and an input of said inverter;

a capacitor coupled between said input of said inverter and said ground; and

a second resistor coupled between said local net and said ground.

6. (Previously Presented) An integrated circuit (IC) output stage protection system, comprising:

a first pair of NMOS devices, each having a gate configured to be coupled to respective IC logic core outputs and a source coupled to a current source;

a second pair of NMOS devices, each having a source coupled to a respective drain of said first pair of NMOS devices and a gate coupled to a biasing circuit that biases said second pair so that said first pair of NMOS devices operate in a saturation region;

a third pair of NMOS devices, each having a source coupled to a respective drain of said second pair of NMOS devices and a drain coupled to first and second output nodes, respectively;

wherein an operating voltage of said first pair of NMOS devices is lower than an operating voltage of said second pair of NMOS devices and said operating voltage of said first pair of NMOS devices is lower than an operating voltage of said third pair of NMOS devices;

a first set of one or more diodes coupled between said first output node and respective gates of said third pair of NMOS devices; and

a second set of one or more diodes coupled between said second output node and said respective gates of said third pair of NMOS devices;

wherein said first and second sets of one or more diodes substantially protect said NMOS devices so that they operate within a device voltage rating.

7. (Previously Presented) The IC output stage protection system of claim 6, wherein said first and second sets of one or more diodes are coupled to said respective gates of said third pair of NMOS devices through a resistor.

8. (Previously Presented) The IC output stage protection system of claim 6, wherein:

 said first pair of NMOS devices comprises a pair of relatively thin oxide devices; and

 said second and third pairs of NMOS devices comprise a first and second pair of relatively thick oxide devices.

9. (Original) The IC output stage protection system of claim 6, wherein said first and second sets of one or more diodes each comprise two diodes.

10. (Previously Presented) The IC output stage protection system of claim 6, wherein at least one of said diodes comprises an NMOS device configured as a diode, said NMOS device having a guard ring coupled to first and second contacts on a P-substrate.

11. (Original) The IC output stage protection system of claim 6, further comprising:

 a first input/output (I/O) pad electrostatic discharge (ESD) protection circuit coupled to said first output node; and

a second I/O pad ESD protection circuit coupled to said second output node.

12. (Previously Presented) The IC output stage protection system of claim 11, wherein said first and second I/O pad ESD protection circuits each comprise:

a first set of one or more diodes coupled between an I/O pad and a local net;

a second set of one or more diodes coupled between a ground and said I/O pad;

an NMOS device having a drain coupled to said local net, a source coupled to said ground, and a gate coupled to an output of an inverter;

a first resistor coupled between said local net and an input of said inverter;

a capacitor coupled between said input of said inverter and said ground; and

a second resistor coupled between said local net and said ground.

13. (Currently Amended) An integrated circuit (IC) output stage protection system, comprising:

first and second input/output (I/O) pad electrostatic discharge (ESD) protection circuits coupled to respective first and second output nodes; and

an output stage, including:

first and second NMOS devices having respective gates configured to be coupled to first and second IC core outputs, respectively, and respective sources coupled to a current source,

third and fourth NMOS devices having respective sources coupled to respective drains of said first and second NMOS devices and respective gates coupled to a biasing circuit,

fifth and sixth NMOS devices having respective sources coupled to respective drains of said third and fourth NMOS devices and respective drains coupled to first and second output nodes, respectively,

wherein an operating voltage of said first and second ~~CMOS~~ NMOS devices is lower than an operating voltage of said third and fourth NMOS devices and said operating voltage of said first and second NMOS devices is lower than an operating voltage of said fifth and sixth NMOS devices;

a first set of one or more diodes coupled between said first output node and respective gates of said fifth and sixth NMOS devices, and

a second set of one or more diodes coupled between said second output node and said respective gates of said fifth and sixth NMOS devices;

wherein said output stage protection system substantially protects said NMOS devices so that they operate within a device voltage rating during IC power up/power down and ESD events.

14. (Previously Presented) The IC output stage protection system of claim 13, wherein said first and second sets of one or more diodes are coupled to said respective gates of said fifth and sixth NMOS devices through a resistor.

15. (Original) The IC output stage protection system of claim 13, wherein said first and second sets of one or more diodes each comprise two diodes.

16. (Previously Presented) The IC output stage protection system of claim 13, wherein at least one of said diodes comprises an NMOS device configured as a diode, said NMOS device having a guard ring coupled to first and second contacts on a P-substrate.

17. (Previously Presented) The IC output stage protection system of claim 13, wherein

said first and second NMOS devices each comprise a 1.2 V device; and

said third, fourth, fifth, and sixth NMOS devices each comprise a 2.5 V device.

18. (Previously Presented) The IC output stage protection system of claim 17, wherein a voltage difference between any two terminals of said first and second NMOS devices does not exceed approximately 1.32 V, and wherein a voltage difference between any two terminals of third, fourth, fifth, and sixth NMOS devices does not exceed approximately 2.75 V.

19. (Previously Presented) The IC output stage protection system of claim 17, wherein said biasing circuit biases said gates of said third and fourth NMOS devices

so a drain voltage of said first and second NMOS devices does not exceed approximately 1.2 V.

20. (Currently Amended) The IC output stage protection system of claim 13, wherein said first and second I/O pad ESD protection circuits each comprise:

a first set of one or more diodes coupled between an I/O pad and a local net;

a second set of one or more diodes coupled between a ground and said I/O pad;

an NMOS device having a drain coupled to said local net, a source coupled to said ground, and a gate coupled to an output of an inverter;

a first resistor coupled between said local net and an input of said inverter;

a capacitor coupled between said input of said inverter and said ground; and

a second resistor coupled between said local net and said ~~ground~~ ground.